



Southern Illinois
University at Carbondale
Carbondale, Illinois 62901

Cooperative Wildlife Research Laboratory
618-536-7766

August 13, 1986

TO: Mr. Jack Ellis, Head
Operations and Planning, IDOC

FROM: Dr. W. D. Klimstra, Director
Cooperative Wildlife Research Laboratory

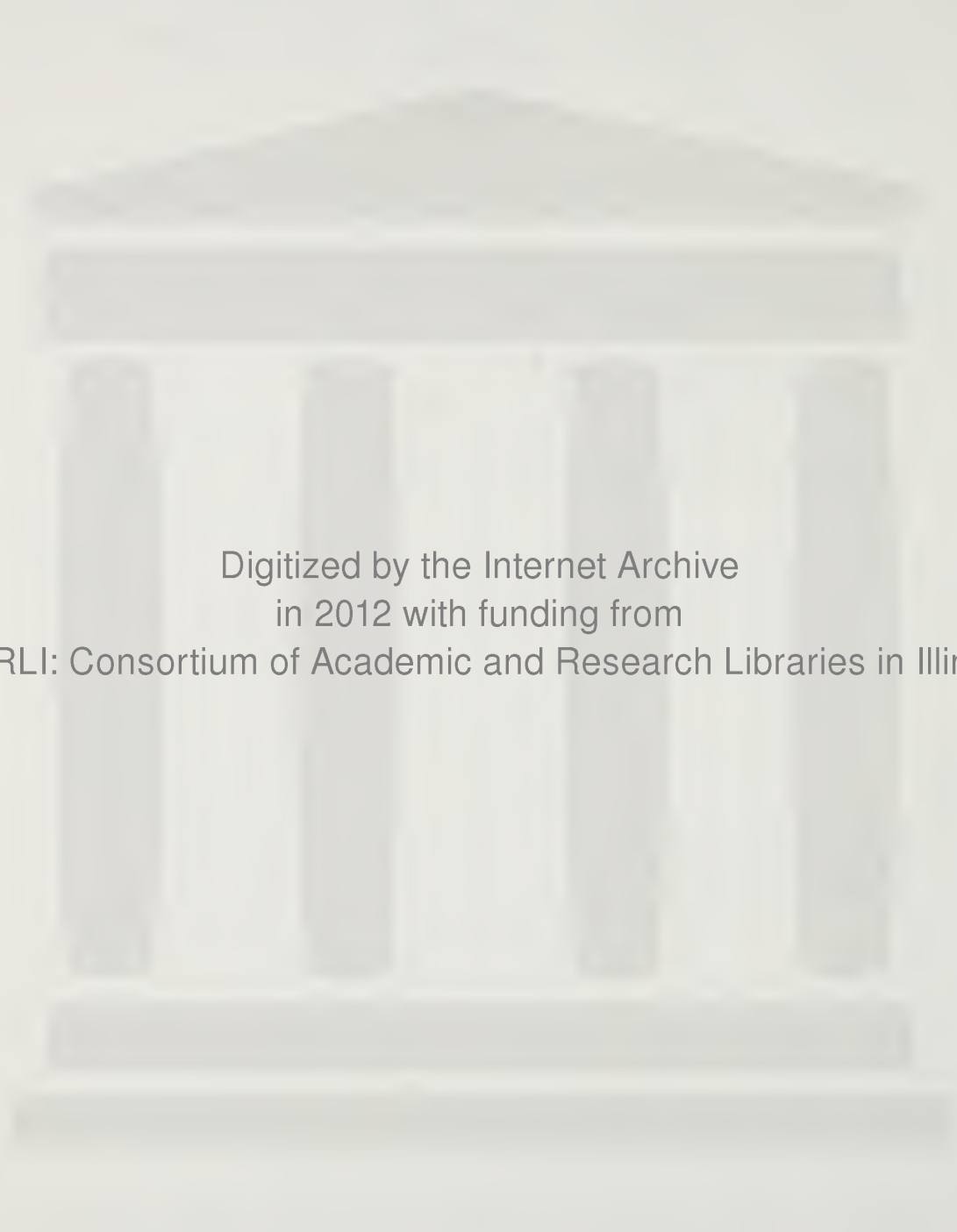
RE: Final Reports for Study IV and Study VI,
Federal Aid Project W-63-R(SI)-28

The final reports for W-63-R(SI)-28 are supplied in accordance with contractual agreements for research dealing with white-tailed deer.

WDK:ah

Enclosures

cc: Mr. James Moak
Mr. Forrest Loomis (w/enc.)
Dr. Alan Woolf



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FINAL REPORT

W-63-R(SI)-28

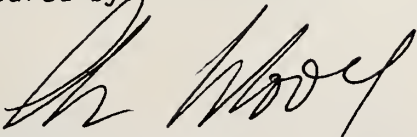
Investigation in heavy metals, toxic contaminants and disease
as related to white-tailed deer in Illinois

Submitted by
Cooperative Wildlife Research Laboratory, SIUC

Presented to
Illinois Department of Conservation

August 13, 1986

Prepared by:



Alan Woolf, Assistant Director
Cooperative Wildlife Research Laboratory
Southern Illinois University
Carbondale, IL 62901

Approved by:



W. D. Klimstra, Director
Cooperative Wildlife Research Laboratory
Southern Illinois University
Carbondale, IL 62901

FINAL REPORT

STATE OF ILLINOIS

W-63-R(SI)-28

STUDY VI

JOBS A,B and C

Project Period: April 1, 1980 through June 30, 1986

Study VI: Investigation in heavy metals, toxic contaminants
and disease as related to white-tailed deer in
Illinois

Prepared by Alan Woolf
Cooperative Wildlife Research Laboratory
Southern Illinois University at Carbondale

Need:

Investigations of diseases and herd health of white-tailed deer (Odocoileus virginianus) in Illinois are important not only to insure the welfare of the species, but also to safeguard state livestock industries and state residents. The abundance of healthy wild animals usually coincides with environmental quality, while conversely, diseases in wildlife populations often serve as an early warning of environmental problems that could endanger human health and welfare.

Objective:

To determine and monitor the health status of white-tailed deer herds in designated portions of Illinois that would reflect environmental quality and serve as "sentinels" of zoonotic diseases and toxic contaminants in the environment.



EXECUTIVE SUMMARY

This project began the last quarter of FY80 (April through June 1980) as W-63-R(SI), Study VIII with 3 Jobs. The study title remained the same, but following an AFA revision, Study designation and Job titles changed. To clarify the contents of this final report, following are Study and Job designations/titles and the duration of each segment:

STUDY VIII (April 1, 1980 through June 30, 1981)

- Job A. Literature Review
- Job B. Herd and Environmental Monitoring
- Job C. Analysis and Report

STUDY VI (July 1, 1981 through June 30, 1982)

- Job A. Herd and Environmental Monitoring
- Job B. Analysis and Report

STUDY VI (July 1, 1982 through June 30, 1986)

- Job A. Herd and Environmental Monitoring
- Job B. Anaplasmosis and Bluetongue in Deer
- Job C. Analysis and Report

Job VIIIA (Literature Review) was completed on schedule and submitted as a Job Completion Report attached to the Annual Performance Report W-63-R(SI)-23, Study VIII, 1981. Further references to Jobs in this final report relate to those identified since July 1981 under STUDY VI. Throughout the duration of this project, data have been analyzed in a timely manner, and results presented in Annual Performance Reports as thorough analyses conducted under Job C. Further, portions of this project represent "surveys of an ongoing nature that need not have a formal final report" (S. Harrison, Ill. Dept. Cons. Fed. Aid Coordinator, Memo dated January 21, 1985). Therefore, this Final Report as required by the Federal Aid in Wildlife Restoration Act



represents a summation of data previously presented. An exception is those data collected during Segment 28 that have not previously been reported.

It is noteworthy that the overall health of the Illinois white-tailed deer herd appears to be excellent. During the project period, reported incidences of disease were rare and limited to infectious and non-infectious diseases known to affect deer. The relatively few necropsies of deer collected from selected herds supported the presumption of good herd health. Serological surveys for selected pathogens did not reveal high seroprevalence of exposure to infectious agents that could pose threat to the deer herd, domestic livestock, or human health.

The public benefit of using the deer herd as a "sentinel" to monitor environment quality was evident by the results of a regional analysis of levels of heavy metals in deer livers. As a result of the study, environmental contamination of Crab Orchard NWR was suspected, authorities were alerted, and the extent of the problem later documented by other researchers.

Job VIA. Herd and Environmental Monitoring

Objective: To determine occurrence and prevalence of infectious diseases in the deer herd and to determine levels of selected heavy metals and toxic chemicals over time by monitoring selected herds.

METHODS

Necropsy

Procedures and protocols were established to provide a regional diagnostic and statewide consultation service for Illinois Department of Conservation (IDOC) staff. A necropsy demonstration and training session was conducted for IDOC staff, primarily regional wildlife managers. This service

was to provide early detection and diagnosis of infectious disease outbreaks. Also, necropsies were performed opportunistically on deer collected by Division of Law Enforcement staff to assess health of selected herds. Health status of deer in specific herds was also acquired in conjunction with W-63-R(SI), Study IV research objectives.

Serology

Infectious diseases known to affect livestock and white-tailed deer were identified by a review of literature (Study VIII, Job A). Anaplasmosis, brucellosis, leptospirosis, bluetongue (BT)/epizootic hemorrhagic disease (EHD), bovine viral diarrhea (BVD), infectious bovine rhinotracheitis (IBR), parainfluenza 3, and vesicular stomatitis (VS) were selected for surveillance. The Crab Orchard NWR deer herd was selected as the primary sentinel herd because of agriculture, livestock, recreation, and wildlife interactions. Appropriate diagnostic tests to detect seroprevalence of exposure to these diseases were performed in collaboration with the Illinois Bureau of Animal Disease Laboratory-Centralia and diagnostic laboratories at the Univ. Ill., College of Vet. Med.

Pesticide Residues

Fat samples were collected from hunter harvested deer at Illinois deer check stations. They were screened for detectable residues of chlorinated hydrocarbons at the Animal Disease Laboratory-Centralia and for chlorinated hydrocarbons, organo-phosphates and organo-nitrates at the Illinois Department of Public Health Laboratory, Springfield Branch.

Heavy Metals

Deer liver samples were obtained from cooperating hunters at Illinois

deer check stations. Liver tissue was oven dried then acid digested for analyses. Concentrations (ppm dry wt. basis) were determined for selected metals using a plasma-spectrophotometer.

RESULTS AND DISCUSSION

Necropsy

Necropsies of 30 deer (7 from Crab Orchard NWR, 21 from Union County Conservation Area, 1 from Sangamon County, and 1 from Johnson County) generally revealed a pattern of good physical condition and health. Exceptions were chronic hepatitis of undefined etiology noted in a yearling male from Union County; coliform enteritis in a neonatal fawn found at Union County; and cachexia associated with previous trauma noted in an adult male collected at Union County. Abomasal parasite counts revealed very low levels of parasitism. Meningeal worms (Parelaphastrongylus tenuis) were found in 3 deer. Ectoparasite burdens (primarily lone star ticks) were moderate to high among deer collected at Crab Orchard NWR, but levels did not appear detrimental to the deer.

Serology

Surveys revealed expected levels of seroprevalence of leptospirosis in the sentinel herd at Crab Orchard NWR. Leptospirosis activity evident in deer varied annually; 30.8% were reactors (titers incomplete >1:100) in one year and 9.1% the following. Seroprevalence of leptospirosis in the sentinel herd (9.1%) did not differ significantly from that detected in deer harvested throughout Williamson County (8.7%) during concurrent sampling periods. These findings are in accordance with published serosurveys (Ferris and Verts 1964) and support the contention that leptospirosis is not a deer herd health

problem nor do deer serve as effective reservoirs of infection for cattle.

Parainfluenza 3 virus exposure was common in deer samples; a 33% seroprevalence was detected. Such exposure rates are common and do not imply a herd health problem. No brucellosis seropositive animals were found among the sentinel herd. Evidence of BVD and IBR exposure was detected only in a single sample from a deer in Randolph County known to have been closely associated with a beef cattle herd. Titers of 1:8 were detected for both agents. The same deer also had a 1:8 titer against BT.

Anaplasmosis and the BT/EHD complex were considered the most important diseases in terms of herd disease potential for either cattle, deer, or both. These were monitored most extensively and are reported separately under Job B.

Serosurveys for VS activity in the sentinel deer herd began in 1985 to determine feasibility of detecting VS activity throughout Illinois using samples from hunter harvested deer. Although antibodies to VS have been detected in numerous wild and domestic species, evidence suggests that wildlife species do not serve as long-term reservoirs for VS, but the presence of serum neutralizing antibodies may provide a means of detecting areas of VS activity (Fletcher et al. 1985). A microtiter serum neutralization test against New Jersey (NJ) and Indiana (I) types was performed on the samples by staff of the Animal Diagnostic Laboratory-Centralia; a titer of 1:64 or greater was presumed positive, although Fletcher et al. (1985) did consider lower titers (1:32) positive.

Sera from 135 hunter harvested deer were tested; 8.9% were seropositive to VS NJ and 5.9% to VS I. The highest end point titer detected was 1:256. Because of no previous evidence of VS activity in the southern Illinois region, these findings were suspect. A subset of 7 samples were suitable for analysis by complement fixation test; all were negative at 1:5 dilution. Remaining samples are pending additional analysis. The positive serum

neutralization results may be due to cross-reactivity with protein or other substance in the deer samples which were taken from field dressed carcasses rather than venipuncture. The sentinel herd and sympatric cattle will be resampled during following project segments to resolve validity of preliminary results and techniques. These preliminary data should not be presumed to indicate VS activity in the sentinel herd.

Pesticide Residues

A total of 197 fat samples were collected from deer harvested in 16 counties representing 4 regions of Illinois plus Crab Orchard NWR in Williamson County (Table 1). Detectable levels of chlorinated hydrocarbons, organo-phosphates and organo-nitrates were not found in samples except for 4 collected from Crab Orchard NWR in 1980 that had traces (0.01-0.03 ppm) of dieldrin. Two of the deer also had traces (0.02 and 0.05 ppm) of hetachlor epoxide. PCB's were not detected in any samples.

Heavy Metals

Analysis of 603 deer livers provided a data base representing 32 counties and Crab Orchard NWR. Detailed findings were previously presented (Ann. Performance Rept. W-63-R(SI)-25, Study VI, 1983; Ann. Performance Rept. W-63-R(SI)-26, Study VI, 1984; Woolf et al. 1982; Woolf et al. 1983). Significant regional variation was found in concentrations of Cd, Co, Cr, Cu, Mg, Mn, Ni, Pb, and Zn (Table 2) in 441 deer livers collected in 1980 and 1981. The addition of 162 samples collected in 1982 changed mean concentrations of some elements, but did not alter the significance of regional variation previously reported. Among the elements tested for, only Cd, Ni and Pb are thought to constitute threat to human health (Jenkins 1981); regional differences in concentrations detected are presented in Table 3.

No Cd levels exceed those reported by Jenkins (1980a) from white-tailed deer livers sampled in Ohio and Tennessee, or livers from various domestic livestock sampled in locations throughout the United States. Although no concentration of Cd found in Illinois deer can be considered unduly high, the mean 0.43 ppm dry wt. found in 150 deer sampled at Crab Orchard NWR was significantly greater than that found in other regions.

The highest mean Ni levels (4.49 ppm) were found in deer from Crab Orchard NWR. None of the levels approached the maximum values reported in mammals from contaminated areas (Jenkins 1980).

The highest mean Pb levels also were found at Crab Orchard NWR. The detection of these lead levels in deer from Crab Orchard led to identification of other contamination in the area and illustrate the value of using wildlife species as sentinels to monitor environmental contamination.

None of the elements tested for were present at levels that appear to pose hazard to either human or deer herd health. Further, the baseline levels are similar to those expected and provide no evidence of heavy metal contamination in Illinois other than the problem noted at Crab Orchard NWR. More widespread and periodic sampling was indicated to further monitor environmental and herd quality throughout Illinois. Liver samples were collected from about 1200 additional deer at check stations throughout the state in collaboration with Dr. L. Hungerford (Dept. Pathobiology, Coll. Vet. Med., Univ. Illinois) during the 1985 deer season. To date, 100 samples have been acid digested and are pending analysis. Laboratory analysis and findings will be reported during continued segments of this study approved under a new AFA.

Job VIB. Anaplasmosis and Bluetongue in Deer

Objective: To determine annual prevalences and herd health consequences of

anaplasmosis and bluetongue/epizootic hemorrhagic disease in sympatric deer and cattle herds.

METHODS

Sera samples were collected from hunter harvested deer at Crab Orchard NWR 1980-85. Sera were collected from representative cattle herds that had grazed on the refuge when they were removed in fall 1981 and 1984. Capillary tube agglutination (CTA) tests were used to test deer and cattle sera for anaplasmosis in 1981; subsequently, all sera was tested by the more sensitive indirect immunofluorescence (IFA) technique. The relative abundance and distribution of tick vectors potentially important in disease transmission were studied by examination of live-trapped and hunter harvested deer 1982-84 and transect sampling for free-living ticks on the refuge summer 1984. These studies were done in collaboration with Drs. R. Smith and L. Hungerford (Dept. Pathobiology, Coll. Vet. Med., Univ. Ill.)

Sera samples for detecting seroprevalence of BT/EHD were concurrently obtained and tested for presence of BT/EHD neutralizing antibodies by agar gel immunodiffusion (AGID). These tests were done in collaboration with R. Hill and J.D. Reynolds (Animal Diagnostic Laboratory, Centralia).

RESULTS AND DISCUSSION

Anaplasmosis

Anaplasmosis is an economically important disease of cattle in Illinois; 35.5% of veterinary practitioners reported evidence of disease (R. Smith, unpubl. data). Significantly, 73.3% of respondents to Smith's survey believed that deer were reservoirs of infection. Field studies have confirmed the importance of black-tailed deer (Odocoileus hemionus columbianus) as reservoirs of bovine anaplasmosis in California, but data from white-tailed

deer vary from one study area to another (Smith et al. 1982). Our 1981 findings of 6.9% seropositive deer at Crab Orchard NWR is much higher than reported for white-tailed deer elsewhere. Concurrent 1981 samples from 54 cattle revealed 13% seropositive by CTA. Two other cattle herds that had grazed on the refuge were tested in 1981 by IFA; 19.2 and 36.8% were positive. Deer tested by IFA in 1982 through 1985 revealed 12.5, 12.5, 11.3 and 18% seropositive in each respective year. Cattle tested in 1984 were 31.8% seropositive. These findings reveal enzootic anaplasmosis in the sentinel deer herd, but sympatric cattle demonstrated 2-3x greater seroprevalences during the same time span. Attempts to isolate the organism from deer and then determine its infectivity in sheep and cattle have failed. Although deer in the southern Illinois region clearly harbor Anaplasma marginale infections, their role in the epizootiology of bovine anaplasmosis remains undefined. Tentatively, it seems that seropositive deer most likely represent a "spillover" of infection from enzootic disease in cattle. No clinical signs of anaplasmosis have been noted among deer from the refuge and the presence of anaplasmosis infections is not assumed to be a herd health problem.

Tick vector ecology studies were reported in detail (Ann. Fed. Aid Performance Rept., W-63-R(SI)-26 and 27, Study VI, 1984 and 1985). Although adult Dermacentor variabilis were over twice as abundant as Amblyoma americanum in the habitats sampled, the most prevalent tick on all deer was Amblyoma. Although vector potential exists, Amblyoma has not been shown to be an effective vector of anaplasmosis. Seasonal tick prevalence on cattle using the refuge is unknown except for fall when only Dermacentor were found on cattle examined.

Bluetongue/Epizootic Hemorrhagic Disease

Evidence of exposure to bluetongue (BT) virus is common among cattle in

Illinois, but clinical disease is rare (R. Hill, Animal Diagnostic Lab., Centralia, pers. comm.). Epizootic Hemorrhagic Disease (EHD) caused by a virus closely related to BT has been reported numerous times enzootic and periodically epizootic in deer herds. Clinical cases of EHD have not been reported in free ranging deer in Illinois. However, hoof lesions suggestive of chronic EHD were observed several times at Crab Orchard NWR and Williamson County deer check stations.

Testing of 2 cattle herds grazing on Crab Orchard NWR in 1981 for exposure to BT/EHD revealed 16.7 and 14.5% seropositive, a rate generally consistent with that found in Illinois cattle. The same year, 3.7% of deer tested at Crab Orchard NWR were seropositive. Seroprevalence of BT/EHD in the Crab Orchard NWR deer herd remained at 3.7% in 1982 then declined to 1.6% in 1983 and 0.7% in 1984. Sampling of cattle in 1984 confirmed the apparent decline in BT/EHD activity; only 2% were seropositive. No seropositive deer were detected in 1985 at either Crab Orchard (n=135) or among 75 deer sampled throughout Illinois.

Epizootiology of BT/EHD in Illinois deer remains unclear. The diseases do not appear to be herd health problems to either deer or cattle at this time. Reasons for the decline in seropositive animals among those tested in southern Illinois are unknown. In 1985, samples of serum extracts were taken from deer livers collected throughout Illinois. If suitable for AGID testing, these will be examined on a regional basis and results compared to a comparable regional collection of cattle serum. These further studies will be conducted during continuing segments of this study under an approved new AFA.

Job VIC. Analysis and Report

Objective: To analyze results from Jobs A and B and prepare and final report, which summarizes and discusses those findings.

This objective has been met through annual reporting of findings, submission of a final report for Study VIII, Job A (Literature Review), the contents of this report, and the following publications:

WOOLF, A., J.R. SMITH, and L. SMALL. 1982. Metals in livers of white-tailed deer in Illinois. Bull. Environm. Contam. Toxicol. 28:189-194.

SMITH, R.D., A. WOOLF, L.L. HUNGERFORD, and J.P. SUNDBERG. 1982. Serologic evidence of Aanpalsma marginale infection in Illinois white-tailed deer. JAVMA 181:1254-1256.

WOOLF, A., C. GREMILLION-SMITH, and C.O. FRANK. 1983. Regional variation in metals in livers of white-tailed deer in Illinois. Trans. Ill. Acad. Sci. 76:305-310.

NELSON, T.A., K.Y. GRUBB, and A. WOOLF. 1984. Ticks on white-tailed deer fawns from southern Illinois. J. Wildl. Dis. 20:300-302.

Original data and copies of Quarterly and Annual Fed. Aid Performance Repts. are on file at the Cooperative Wildlife Research Laboratory, Southern Illinois University at Carbondale, Carbondale, IL 62901.

RECOMMENDATIONS

1. Continue to monitor environmental quality by studies of tissues obtained primarily from hunter harvested deer with emphasis on:
 - a. Expanding the existing data base on regional variation of levels of heavy metals present in deer livers.
 - b. Detection of changes in regional baseline levels of heavy metals present in deer livers over time.
2. Continue to monitor BT/EHD activity in a sentinel deer herd and in selected regions of the state to detect enzootic foci and temporal variation in prevalence.
3. Determine if vesicular stomatitis activity is evident in Illinois using hunter harvested deer as sentinel animals.

4. Initiate surveys to determine if Lyme disease is present in Illinois deer herds and to assess public health implications if the disease is detected.
5. Provide recurrent training to Illinois Department of Conservation staff and encourage submission of diagnostic cases to insure timely detection and diagnosis of disease occurring in deer.

LITERATURE CITED

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- Jenkins, D.W. 1980. Biological monitoring of toxic trace metals: Volume 1. Biological monitoring and surveillance. United States Environmental Protection Agency, EPA-600/3-80-089:1-215.
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- Smith, R.D., A. Woolf, L.L. Hungerford, and J.P. Sundberg. 1982. Serologic evidence of Anaplasma marginale infection in Illinois white-tailed deer. JAVMA. 181:1254-1256.
- Woolf, A., J.R. Smith, and L. Small. 1982. Metals in livers of white-tailed deer in Illinois. Bull. Environm. Contam. Toxicol. 28:189-194.
- Woolf, A., C. Gremillion-Smith, and C.O. Frank. 1983. Regional variation in metals in livers of white-tailed deer in Illinois. Trans. Ill. Acad. Sci. 76:305-310.



Table 1. Numbers of white-tailed deer fat samples collected by Illinois county and Department of Conservation Management region for pesticide and insecticide residue analyses, 1980, 1981, and 1984.

Region	County	1980	1981	1984	Total
1	JoDavies	0	10		10
2	DeKalb	0	10		10
3	Fulton	0	10		10
	Knox	0	11		11
	Peoria	0	9		9
	Rock Island	0	10		10
	Tazewell	0	9		9
	Warren	0	1		1
	Woodford	0	11		11
			<u>61</u>		<u>61</u>
8	Gallatin	1	0		1
	Hardin	29	0		29
	Johnson	7	0		7
	Pope	0	2		2
	Saline	0	8		8
	Union	0	10		10
	Williamson	0	10		10
		<u>37</u>	<u>30</u>		<u>67</u>
	*CONWR	24	0	25	49
	GRAND TOTAL	<u>61</u>	<u>111</u>	<u>25</u>	<u>197</u>

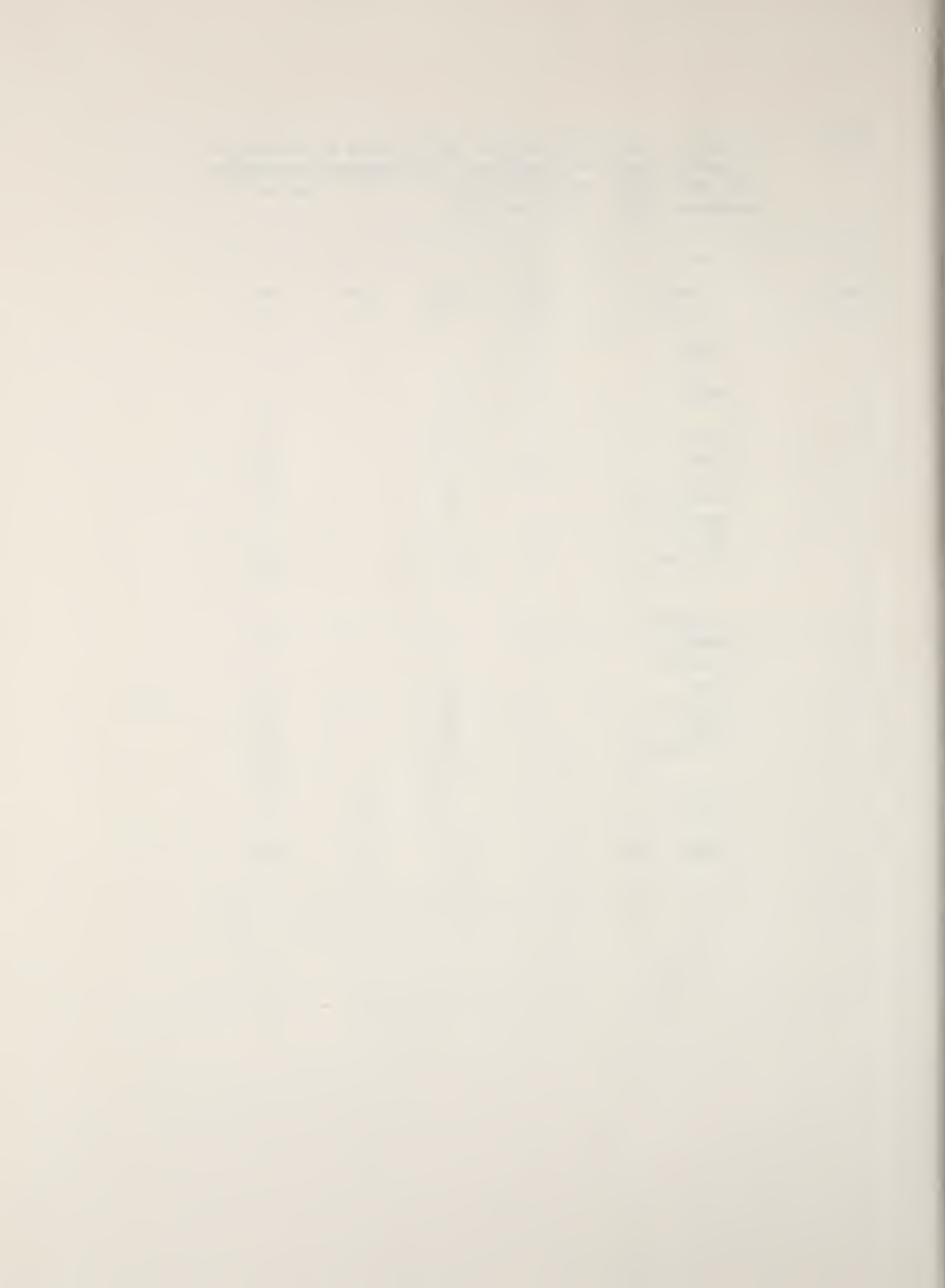


Table 2. Regional mean trace metal content of Illinois white-tailed deer liver tissue, 1980 and 1981 (ug/g dry wt.)

Element	Total ^a (n = 441) X ± SE	Crab Orchard ^a NWR (n = 151)	W. Central ^b Ill. (n = 188)	S. Ill. ^c (n = 57)	N. Ill. ^d (n = 45)
Cadmium	0.23 ± 0.02	0.43 ^e (a)	0.10 (c)	0.25 (b)	0.09 (c)
Cobalt	0.20 ± 0.02	0.36 (a)	0.05 (b)	0.45 (a)	0.04 (b)
Chromium ^f	2.7 ± 0.1	3.1 (a)	2.3 (b)	1.0 (c)	
Copper	76 ± 3	115 (a)	56 (b)	49 (b)	55 (b)
Magnesium	206 ± 3	211 (b)	212 (b)	154 (c)	235 (a)
Manganese	5.9 ± 0.2	8.4 (a)	5.0 (b)	3.9 (b)	4.0 (b,c)
Nickel	2.5 ± 0.3	4.5 (a)	1.7 (b)	0.8 (b)	1.0 (b)
Lead	2.8 ± 0.2	5.6 (a)	1.3 (b,c)	2.1 (b)	0.3 (c)
Zinc	65 ± 2	69 (a)	61 (a,b)	55 (b)	67 (a)

^aCrab Orchard National Wildlife Refuge located in Williamson Co., Southern Illinois

^b15 counties represented

^c5 counties represented

^d6 counties represented

^eMeans with the same letter are not significantly different (Duncan's Multiple Range Test)

^fChromium only tested for in 1980 samples, n = 205

Table 3. Regional mean concentration (ppm dry wt.) of cadmium, nickel, and lead found in Illinois white-tailed deer livers, 1980-82.

Geographical Region	Sample Size	Mean Concentration ± SE		
		Cd	Ni	Pb
thern Illinois	156	0.18 ± .02	2.0 ± 0.3	1.0 ± 0.2
t central Illinois	196	0.11 ± .01	1.7 ± 0.1	1.4 ± 0.4
tern Illinois	9	0.19 ± .06	2.1 ± 0.9	2.3 ± 0.8
thern Illinois	92	0.25 ± .02	1.3 ± 0.2	2.1 ± 0.3
b Orchard NWR	150	0.43 ± .04	4.5 ± .08	5.6 ± 0.2



